

Food waste management: an example from university refectory

FWM in
university
refectory

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Abstract

Purpose – The study analysed the amount of plate waste in a university refectory in Izmir, Turkey to find ways of minimizing plate waste in the university, providing sustainability and contributing to the development of circular economy and raising awareness about the plate waste problem.

Design/methodology/approach – Observation and semi-structured interviews were used to determine the volume of plate waste and level of awareness of academicians, students and administrative staff and suggest sustainable solutions for food waste in university refectories. The data gained from the semi-structured interviews were analysed with qualitative analysis software (MAXQDA®).

Findings – Plate waste in the university's refectories is increasing due to the lack of precautionary measures. Academicians, students and administrative staff all showed low awareness rates.

Originality/value – This study is original in investigating theoretically and empirically one of the main reasons for food waste, namely plate waste in mass consumption sites, and evaluating the effect of food waste from an economic, social and environmental perspective.

Keywords Food waste, Mass consumption, Observation, Semi-structured interview

Paper type Research paper

1. Introduction

Global food demand is projected to increase 60–110% between 2005 and 2050 due to population growth (Tilman *et al.*, 2011; Alexandratos and Bruinsma, 2012; Hic *et al.*, 2016) while about 1.3 billion tons of food per year is lost or wasted (FAO, 2011). Consequently, food loss and waste are a critical issue for the world and the future.

Food loss and waste (FLW) occurs in the food supply chain (FSC) (Gustavsson *et al.*, 2011) at various stages (FAO, 2011). Food waste is particularly common in developed countries, whereas food losses more often occur in emerging economies. In general, 40% of food is lost or wasted in all countries (Godfray *et al.*, 2010). The High-Level Panel of Experts (HLPE) (2014) defined food waste as “the food suitable for human consumption, discarded or left to be spoiled at the level of the product, regardless of the cause”. Food waste arises from discarding food fit for human consumption in the final stages of the food supply chain (Salihoglu *et al.*, 2018). Food loss refers to reduced food quantity or quality due to inadequate post-harvest systems and infrastructural capacity (FAO, 2011).

The FSC includes agricultural production, postharvest handling and storage, processing and packaging, distribution and consumption (Elik *et al.*, 2019). The causes of FLW vary at each stage of the FSC (see Figure 1): environmental factors, lack of technology and diseases during agricultural production (HLPE, 2014); inadequate storage facilities and techniques during post-harvest handling and storage, poor supply chain management and improper packing during processing and packaging (Ishangulyyev *et al.*, 2019); unsuitable transportation conditions and insufficient truck capacity during distribution stage (Parfitt *et al.*, 2010); spoilage, oversized portions, expired food and plate waste during consumption (Ishangulyyev *et al.*, 2019).



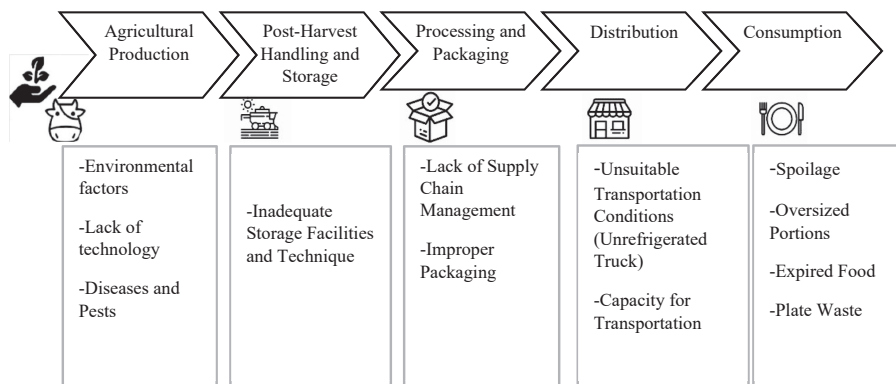


Figure 1.
Reasons for FLW in
FSC (FAO, 2016)

69% of total food waste comes from consumption and some losses occur during food preparation, spoilage due to incorrect preservation and cooking (Nguyen, 2018). However, plate waste, meaning edible food left on the plate from the meal served (Williams and Warton, 2011; Miroso *et al.*, 2016), is particularly serious problem. Consumers waste 35% of their food in households, restaurants and mass consumption places (refectories, hotels, etc.) (Lipinski *et al.*, 2013) while, globally, 80% of people cause food wastage by leaving food on their plates (Gustavsson *et al.*, 2011). While food losses during production are caused by technological inadequacies and environmental factors, plate waste is generally due to a lack of awareness and the eating habits of consumers (Williams and Warton, 2011). Therefore, plate waste should be a priority for research.

As the largest contributor to food waste during consumption, households have been the focus of considerable research (Engström and Carlsson-Kanyama, 2004). However, food waste also occurs on a larger scale, especially in public places like restaurants, cafeterias and canteens (Baig *et al.*, 2019). Food surplus refers to eatable food that is deliberately discarded, withdrawn from sale (e.g. in a grocery store) or not consumed for some other reason. Food surplus turns to food waste when it becomes inedible (Jurgilevich *et al.*, 2016).

There are several reasons for focusing on food waste generation in universities (Abdelaal *et al.*, 2019; Altintzoglou *et al.*, 2021; Leal Filho *et al.*, 2021). Although food/plate waste is a crucial issue for education institutions, they have not implemented sufficient rules or taken other steps to prevent from increasing. Second, universities include people with knowledge and experience who can easily promote change in their environment. Third, food waste is growing in mass consumption places such as university refectories (Gallardo *et al.*, 2016). Fourth, although many universities have investigated waste management plans, few studies have focused on food waste generation and reduction methods in terms of sustainability and the circular economy (Ciccullo *et al.*, 2021).

As mentioned before, increasing population and demand threaten sustainability, causing the traditional linear “buy, do and sell” model to become obsolete. Sustainability means not only doing what is right for the environment but also benefiting economically and socially (Antón-Peset *et al.*, 2021). It is also circular rather than linear in that resources are recovered with the highest possible quality, reused and kept in use for as long as possible. This approach that manage resources is known as the circular economy (Despoudi *et al.*, 2021). Regarding food waste specifically, environmental, social and economic sustainability can be improved by considering this problem within the framework of the circular economy.

While food waste levels are high and there is increasing research into plate waste (Wu *et al.*, 2019; Derqui *et al.*, 2020; Richardson *et al.*, 2021; Visschers *et al.*, 2020; Garcia-Herrero

et al., 2021; Qian *et al.*, 2021), to our knowledge, no previous study has used both observation and semi-structured interview to evaluate plate waste in terms of the three dimensions of sustainability (economic, environmental and social). For example, Derqui *et al.* (2020) focused on only two dimensions: social and environmental.

To sum up, it is crucial to investigate theoretically and empirically one of the main causes of food waste, namely plate waste in mass consumption settings from sustainability and circular economy perspective. The main motivation of this study is thus to analyse food waste in mass consumption places and suggest sustainable solutions from a circular economy perspective to reduce food waste by changing consumer awareness. Through this contribution, the study aims to provide a guide for academicians and managers of mass food consumption sites to consider for their research and food management practices. The study addresses the following two research questions:

RQ1. What are the reasons for plate waste in university refectories?

RQ2. What are the sustainable solutions from a circular economy perspective for reducing plate waste in university refectories?

To address these research questions, we first conducted a detailed literature review about food waste and plate waste. Then, to determine the volume of food waste that occurs in one university, observations were conducted on academicians, students and administrative staff. After proving that there is a high level of food waste, we conducted semi-structured interviews with 150 participants, specifically academicians, students and administrative staff, to determine their level of awareness about food waste. Moreover, qualitative content analysis of the data is conducted by MAXQDA®. Furthermore, by using the Food Waste Calculation tool (SavingFood, 2020), it is aimed to find the economic loss of food waste in the university cafeteria and its equivalent in CO₂ emissions.

The remainder of the paper is structured as follows. Section 2 provides the literature review about food waste and plate waste. Section 3 covers the methods used in the case study of one university refectory and the results. Section 4 suggests some managerial implications while Section 5 concludes by discussing the findings, identifying limitations and suggesting future research.

2. Literature review

The literature review is divided into two sections. The first briefly explains food waste before the second discusses recent studies of one of the main causes of food waste, namely plate waste.

2.1 Food waste

Studies of food loss within the FSC have focused on production (Lapidge, 2015; Redlingshöfer, 2017; Kazancoglu *et al.*, 2018; Ishangulyyev *et al.*, 2019) and post-harvest and processing (Ishangulyyev *et al.*, 2019; Kayikci *et al.*, 2019; Verma *et al.*, 2019). Many studies have investigated the causes and impacts of food waste (Parfitt *et al.*, 2010; Garrone *et al.*, 2014; Giroto *et al.*, 2015; O'Donnell *et al.*, 2015; Baglioni, 2017; Borrello *et al.*, 2017; Raak *et al.*, 2017; Vilarino *et al.*, 2017; Bhatt, 2018; Kiss *et al.*, 2019).

Food waste is defined as “materials for human consumption that are subsequently discharged, lost, degraded, or contaminated”, including leftovers from restaurants, residences, cafeterias, markets and canteens (Peng and Pivato, 2019; Zhao and Manning, 2018). Environmental, economic and social damage is caused by food waste (Mourad, 2016). Environmentally, food waste adds to greenhouse gas emissions, air and water pollution, loss of nutrition on natural resources and habitat degradation (FAO, 2013). Economically, food waste causes revenue losses and economic damage (Ferreira *et al.*, 2013; Kotykova and

Babych, 2019). Socially, food waste has crucial impacts, such as increased hunger and poverty (Kotykova and Babych, 2019).

Various studies have investigated causes and effects of food waste in terms of the three dimensions of sustainability: environmental (Babbit, 2017; Burke and Napawan, 2019; Slorach *et al.*, 2020; Krishnan *et al.*, 2020) economic (Babbit, 2017; Kotykova and Babych, 2019; Slorach *et al.*, 2020) and social (Burke and Napawan, 2019; Kotykova and Babych, 2019).

Global food waste accounts for nearly 25% of all food produced of which 24–30% occurs during production, 20% during post-harvesting processes and 30–35% during consumption (Vilarino *et al.*, 2017). More specifically, consumers waste 35% of their food in households, restaurants and mass consumption places (e.g. refectories and hotels). Thus, given the important role of consumption habits in total food waste, it is crucial to find permanent solutions in consumption places. It is particularly important to focus on plate waste among food waste rather than other causes of FLC.

2.2 Plate waste

Plate waste, referring to food that consumers in mass consumption sites buy but do not eat (Papargyropoulou *et al.*, 2019), is one of the most important causes of food waste (Miroso *et al.*, 2016). High levels of plate waste not only harm the economy but also the environment and social life (EEA, 2019; Barilla Center, 2012).

Various studies have investigated plate waste in mass consumption settings like universities, schools, hotels and hospitals. Tomaszewsk *et al.* (2021) found that the majority of food is wasted but specifically due to plate waste in hotels. They suggested educating employees to reduce food wastage. Ghanem (2020) used a qualitative approach to investigate food waste in hospitals and suggested new policies to reduce it, such as menu planning, storage and food marketing. Papargyropoulou *et al.* (2019), who also focused on food waste in hospitals, suggested food waste prevention strategies for the hospitality and food service (HaFS) sector. Dolnicar *et al.* (2020) analysed the drivers of plate waste in the tourism and hospitality sector. They state that plate waste threatens to environment and it is important cost factor for hotels.

Various studies have focused on schools and university canteens (Wu *et al.*, 2019; Boschini *et al.*, 2020; Derqui *et al.*, 2020; Richardson *et al.*, 2021; Visschers *et al.*, 2020; García-Herrero *et al.*, 2021; Qian *et al.*, 2021; Zhao *et al.*, 2019; Antón-Peset *et al.*, 2021; Kasavan *et al.*, 2021; Leal Filho *et al.*, 2021). Of these studies, Visschers *et al.* (2020) investigated plate waste in two university canteens, including both the level of waste and consumer behaviours. They observed that smaller portions help reduce food waste. Derqui *et al.* (2020) used a survey and clustering methodology to analyse the student behaviours that cause food waste in school canteens and raise awareness about plate waste. They found that schools only follow social and environmental policies to reduce food waste. Similarly, Liu *et al.* (2016) measured plate waste in school canteens and investigated solutions through semi-structured interviews and questionnaires. They found that averagely generated by students is 130 g/cap/meal, means that 21% of total food served. Falasconi *et al.* (2015) investigated the causes of food waste in six schools' canteens to find solutions to reduce it from an economic and environmental perspective. Serebrennikov *et al.* (2020) studied fruit and vegetable food waste in schools. They found that the nutrition education program they applied could not change the amount of fruits and vegetables that students chose. They also find no significant difference in the amount of fruits and vegetables wasted by students in the treatment and control group. Schwartz *et al.* (2015) analysed from a school student health perspective how their behaviour changes when new meals are introduced. In this study, the preparation of new food types with a student perspective has ensured that the students do not create plate waste.

The studies reviewed so far have generally considered food waste in terms of consumer health problems or consumer behaviours regarding food waste. While some studies have incorporated the three dimensions of sustainability in suggesting food waste solutions, there

is a gap in the literature about how to reduce food waste in mass consumption places in terms of all three dimensions of sustainability (economic, environmental and social) and the circular economy. For example, [Boschini et al. \(2020\)](#) focused on plate waste in school canteens. Despite noting that increasing food waste threatens sustainability, they did not address the separate dimensions. However, it is crucial to determine the levels and effects of food waste, especially plate waste, in mass consumption places to take precautions to reduce plate waste and find sustainable solution. [García-Herrero et al. \(2021\)](#) investigated food waste in US school canteens from a sustainability perspective. Generally, studies only cover one or two dimensions of sustainability ([Conrad and Blackstone, 2021](#)) for reducing food waste in mass consumption places. However, it is important not only to reduce food waste but also to contribute to sustainability by evaluating food waste from economic, social and environmental perspectives.

3. Case study: university refectory

The study was conducted in one of the largest and most important universities in Izmir, Turkey, which has over 600 academic and administrative personnel, and over 10,000 students. The study investigated both refectories at the university. Given that there are 205 universities in Turkey, better management of food waste could have significant economic and environmental benefits.

3.1 Method and data collection

Two qualitative research techniques were used, observation and semi-structured interviews, to triangulate data collection. Qualitative research aims to find the meanings of perceptions holistically outside the laboratory environment ([Priyadarshini, 2020](#)). The study consists of two steps. First, observations were conducted to critically assess the generation of food waste in the university's refectories. Second, based on the observation results, interview questions were prepared for semi-structured interviews to assess the awareness of refectory users and identify sustainable solutions to reduce food waste. For qualitative content analysis of the data is conducted by MAXQDA® and all data are categorised and coded for analysis.

3.1.1 Observation and findings. The observations were important to confirm whether the participants' actions matched their responses in the interviews and to determine the magnitude of the problem ([Williams and Cutler, 2020](#)). Observations were conducted in both refectories simultaneously from 11:30 a.m. to 14:30 p.m. during 25–29 November 2019 to determine the amount of plate waste. Observations were recorded on an Excel spreadsheet, as exemplified in [Table 1](#). For each plate of food, the observer marked the remaining food or, if there was no waste, selected the no-waste option. The numbers in the left-hand column represent the number of trays while each cross represents one plate. These mentioned table d'hôte trays have several dishes. Moreover, three people conducted the observations in each refectory. Observation enabled us to see the total number of people eating at each university refectory over the research period and how frequently food was wasted by the end of each lunch time.

Out of 3,883 trays observed in the two refectories, 2,225 contained food waste. [Figure 2](#) shows the food waste generated categorised by food type. The most waste was observed for the main dish (26%), followed by salads (21%) and rice or pasta (17%). These observations indicate that food waste is a critical problem in this university.

The main findings from the observations can be summarised as follows:

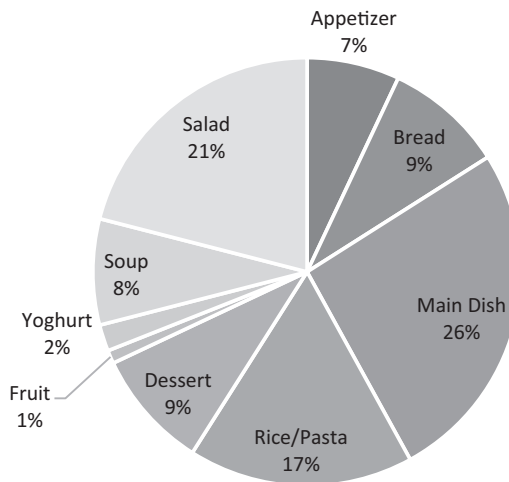
- (1) Most waste was observed in the main meal group.
- (2) Salads were the most frequently wasted supplementary dishes.
- (3) Fruits and beverages were rarely wasted.

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	Soup	Main course	Rice/Pasta	Yoghurt	Fruit	Dessert	Salad	Bread	Appetizer	Non-waste
1	X		X							
2		X		X						
3		X								
4		X								
5			X			X				
6										
7	X								X	
8										X
...		X	X							

Table 1.
An example of filled excel sheet

Figure 2.
Food waste rate in university refectories categorised by food type



To find sustainable solutions for food waste in this university's refectories, it is necessary to understand the level of awareness about the causes of food waste in the university. Therefore, semi-structure interview is implemented as explained in the following section.

3.1.2 Semi-structure interview. Semi-structured interviews are often preferred in qualitative research because they combine standardisation and flexibility, eliminating the limitations of writing and completing questionnaires while providing in-depth knowledge on a particular subject (Liu *et al.*, 2016). In semi-structured interviews, some questions are standardised while others are open-ended (Okumus, 2020), which enables the researcher to obtain in-depth information (Filimonau *et al.*, 2020).

Based on the observations, we prepared semi-structured interview questions to assess the awareness of consumers in the university's refectories. Interviews were conducted with 150 participants, including academicians, students and administrative personnel. The selection of group of people in the university was done through convenience sampling which is a method of using respondents that are conveniently located around a location (Edgar and Manz, 2017).

There were 14 open-ended questions categorised in five main dimensions: general questions, causes of plate waste, challenges of decreasing plate waste, suggestions for reducing plate waste and the impacts of plate waste from the sustainability perspective.

The general dimension included questions related to food waste, such as frequency of eating, level of satisfaction with meals and frequency of meals on the plate. The causes of plate waste dimension included a question to identify why people leave food on their plate. The challenges of plate waste dimension included a question to determine factors that prevent the reduction of food waste in the university refectories. The suggestions for plate waste dimension analysed what can be done in the university by individuals or organisations to reduce food waste in the university refectories. The impacts of plate waste, which was based on sustainability dimensions, analysed the economic, environmental and social effects of food waste. [Table 2](#) shows the literature review of semi-structured interview questions.

The demographic characteristics of the interview participants are shown in [Table 3](#). The participants were between 20 and 50 years old, with approximately equal percentages of women and men. Moreover, the numbers of participants who are students, administrators and academics are equal.

For data analysis, coding process is completed by using the software MAXQDA, which is one of the qualitative data analysis software. MAXQDA is a comprehensive qualitative data analysis software where many qualitative data analysis methods such Focus Group, Content Analysis, Case Studies i.e. can be easily implemented ([Kuckartz and Rädiker, 2019](#)). It is useful to provide researchers to encode data, analyse and visualise results ([Elaldi and Yerliyurt, 2017](#)). Moreover, according to given answers by interviews, a categorisation is created within the program and these categories are defined by coding. In our study, it was aimed to create a systematic structure by including key terms and answers in the code. The coded data were collected under a single category after finalisation. A total of 1,224 coding are completed. The coding process has been validated multiple times for reliability.

[Table 4](#) shows the categories, codes and sub-codes for the analysis. Sub-codes are written in italics in the table.

After completing categorisation and coding, the visual map of the categories and codes shown in [Figure 3](#) is obtained. The thick arrows in the codes are the codes with the highest frequency.

The interview findings are discussed below in the following five sections corresponding to the five dimensions. Satisfaction, hygiene problems and awareness level for plate waste were discussed in general dimensions and coded as they are important subjects of the study.

3.1.2.1 Satisfaction. FSCs face increased consumer demands for food quality and sustainability ([Van Der Vorst et al., 2009](#)). It is thus crucial to ensure food quality to prevent plate waste in the university's refectories. Most of the participants complained about the taste of the food, believing that the meals contained excessive oil and were not cooked well. One of the participants mentioned that she left food on her plate because she did not like taste of food. According to results, the most dissatisfaction factor among participants is "unhealthy food". Moreover, serving "taste of food", "variety problems" and "insufficient portions" are other factors causes dissatisfaction of participants.

Some of the answers obtained in the study are given as examples.

I am satisfied with the food because it contains excessive oil (Student, 19, Man)

I usually leave food on my plate because I am not very satisfied with the taste of the food (Administrative Personnel, 34, Woman)

3.1.2.2 Hygiene problems. According to results, most of participants states that they have hygiene problem when they're eating their food in university refectories. They mostly faced with "foreign object in the food", "dirty cutlery" and "degenerate image" problems in university refectories.

Some of the answers obtained in the study are given as examples.

I once saw an insect in my food. (Administrative Personnel, 33, Man)

Authors	Questions
<i>Lee et al. (2005)</i>	<i>GENERAL QUESTIONS</i> Do you like the food menus served in our university refectory? If your answer is no, please give your reasons
<i>Alooh (2015), Abdelaal et al. (2019)</i>	How often do you leave food on your plate? (For ex: every time, 2–3 times a week, never etc.)
<i>Mol (2013)</i>	What kind of food (main dish, auxiliary food, fruit, dessert, etc.) do you usually leave on your plate?
<i>Alooh (2015), Luecke (2015)</i>	How would you rate your awareness about plate waste as a problem for our university refectory? (1- low, 5- high)
<i>Naithani et al. (2009), Merrow et al. (2012)</i>	Do you think that the leftovers we left in our plates cause a problem for our university refectory? If your answer is yes, please explain your reason(s)
<i>Blackwell (1969)</i>	<i>REASONS OF PLATE WASTE</i> Did you encounter any problems such as hygiene problem (occurrence of foreign object in your food (stones, stalks, glass, metal, insects etc.), or not complying with the certain specifications etc.
<i>Lorenz et al. (2017)</i>	What is/are the reason (s) for you to leave food on your plate? (For ex: not being hungry enough, not loving food, not having enough time to eat, portion size, getting more than you can eat, etc.)
<i>Nguyen (2018), Abdelaal et al. (2019)</i>	<i>CHALLENGES OF DECREASING PLATE WASTE</i> What are the challenges of reducing food waste in our university refectory?
<i>Pirani et al. (2016), Alooh (2015), Şahin and Bekar (2018), Abdelaal et al. (2019)</i>	<i>SUGGESTIONS FOR PLATE WASTE</i> Do you have any suggestions for reducing plate waste in our university refectory?
<i>Alooh (2015), Luecke (2015), Şahin and Bekar (2018)</i>	What role do you play in the prevention of plate waste in our university refectory? What do you pay attention to prevent plate waste?
<i>Pirani et al. (2016)</i>	Do you have any suggestions on how to utilise plate waste in our university refectory?
<i>Muir et al. (2019)</i>	<i>IMPACTS OF PLATE WASTE BASED ON SUSTAINABILITY</i> How would you evaluate the environmental impact of the leftover food at our university refectory?
<i>Şahin and Bekar (2018)</i>	How would you evaluate the economic effect of the leftover food at our university refectory?
<i>Evans (2011)</i>	How would you evaluate the social impact of the leftover food at our university refectory?

Table 2.
Literature review of semi-structured interview questions

	N	%
<i>Gender</i>		
Female	72	48
Male	78	52
<i>Age</i>		
18–25	52	34.7
26–35	56	37.3
36–45	36	24
46–55	5	3.3
56 and more	1	0.7

Table 3.
Demographic characteristics of interview participants

Categories	Codes and sub-codes
Satisfaction	Satisfied Unsatisfied <i>Taste of Food</i> <i>Insufficient Portion</i> <i>Variety Problems</i> <i>Unhealthy Food</i>
Hygiene Problems	No Yes <i>Dirty Cutlery</i> <i>Degenerate Image</i> <i>Foreign Object in the Food</i>
Awareness Level for Plate Waste	No Awareness Low Intermediate High Very High
Reasons for Plate Waste	No Idea Unhealthy food Portion Size Taste Problems Not being hungry enough
Challenges to Decrease Plate Waste	No Idea Agreements with Catering Firm Awareness of Consumer Economic Problems Policies about Improvement in Food Quality Awareness of Manager
Suggestions for Reducing Plate Waste	No Idea Waste Sorting System Pricing Buffet Station Options in Portion Size Increase in Awareness Waste Management Policies Improvement in Food Quality Giving to Animal Shelter Getting as much as we can eat
Impacts of Plate Waste in Terms of Sustainability	Negative Economic Impact Economic Loss Negative Environmental Impact Carbon Emission Negative Social Impact Poverty

Table 4.
Categories, codes and
sub-codes

“I have encountered a problem while I was eating foods, I found hair in my food”. (Student, 24, Woman)

3.1.2.3 Awareness level for plate waste. Consumers’ behaviour regarding food waste is greatly affected by their level of education and knowledge (Chalak *et al.*, 2016). Lack of awareness regarding food waste is one of the reasons for the slow progress in reducing food waste (Derqui *et al.*, 2020). Consumers are the final actors in FSCs (National Research Council, 2015). According to Nikolaus *et al.* (2018), awareness primarily stems from own or friends’ knowledge and behaviours. That is the decision to eat or waste leftover food depends on the

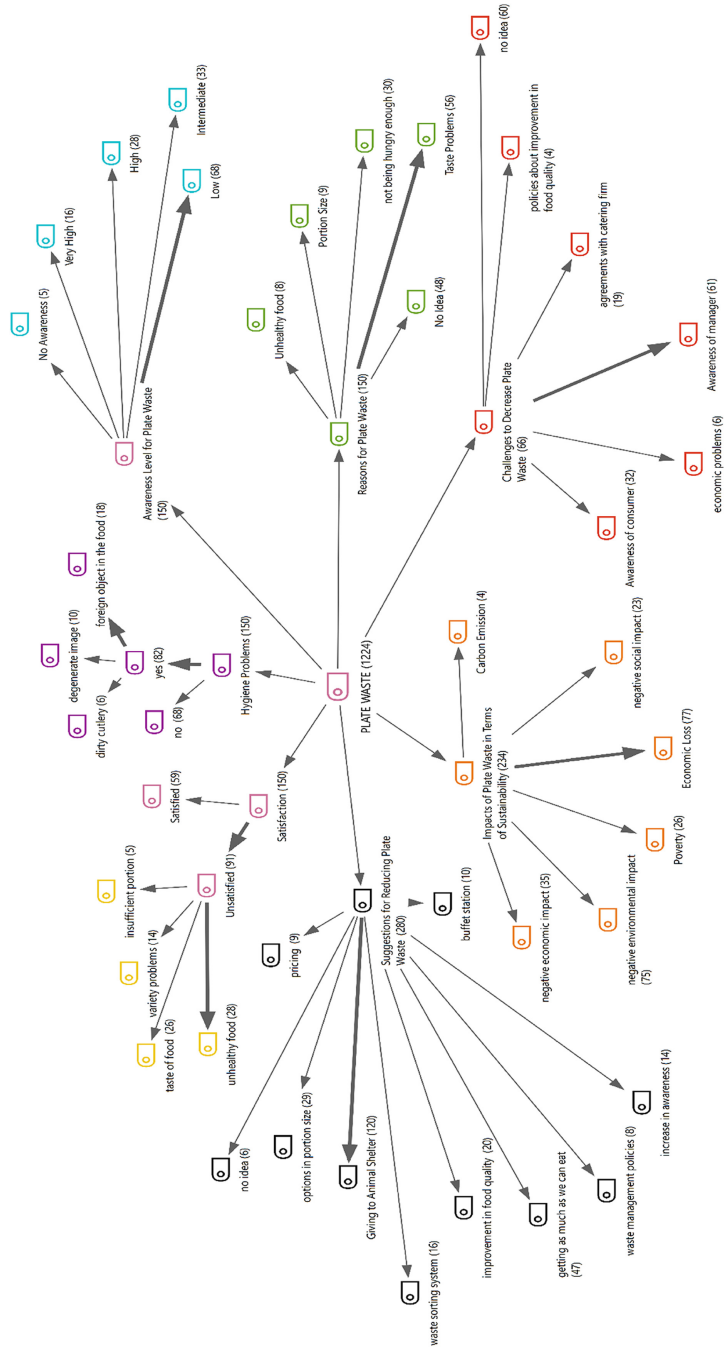


Figure 3.
The visual map of categories and codes

actions of accompanying peers. Hence, identifying the causes of plate waste will help to reduce waste in university refectories, which are revealed as wasting large amounts of food.

According to analysis, for most participants, it is found that their level of awareness was “low”, a lack of consumer awareness regarding plate waste is apparent from the interview answers. The majority of the participants admitted wasting food. For example, one of the academicians said she left food on her plate if it was not fresh while one of the administrative staffs said that she leaves food on her plate 1–2 times in a week, which is a high frequency.

3.1.2.4 Reasons for plate waste. According to the research, the majority of the participants stated that reasons of plate waste caused by “taste of food” and “not being hungry enough”, respectively. Moreover, other participants do not know why they have plate waste, saying they have “no idea”. For example, the academicians found the meals are oily, tasteless and not fresh while the students disliked the foods served and administrative personnel believed that portions were excessively large. [Nikolaus *et al.* \(2018\)](#) also found that large portion sizes cause food waste in grocery store and restaurants in the USA. [Kim and Morawski \(2012\)](#) found that removing trays in university refectories reduced food waste.

Some of the answers obtained in the study are given as examples.

Meals are oily and tasteless (Academician, 33, Woman)

I think the portions are more than necessary. (Administrative Personnel, 34, Woman)

I do not like the food (Student, 28, Man)

3.1.2.5 Challenges to Decrease Plate Waste. According to analysis, participants stated that decreasing plate waste has many challenges such as “awareness of managers”, “awareness of consumer”, “agreements with catering firm”, “economic problems”, “policies about improvement in food quality”.

Some of the answers obtained in the study are given as examples.

I think main problem is the agreements between university refectory and catering firm (Academician, 45, Woman)

No matter how much warning is given to people, the desired effect cannot be achieved. (Administrative Personnel, 50, Woman)

“People are not conscious about reducing food waste.” (Student, 21, Woman)

3.1.2.6 Suggestions for reducing plate waste. According to research analysis, participants suggested that the remaining food should be given to “animal shelters”. Participants suggested that plate waste could be prevented by “improvement in food quality”. Moreover, improvement in “waste management policies”, creating “buffet stations”, “pricing”, “increase in awareness” and organising “options in portion size” are other suggestions to reduce plate waste in university refectories. Indeed, [Derqui *et al.* \(2016\)](#) showed that food waste is significantly lower with this system than when serving staff determine the quantity. In addition, participants suggested “pricing” each dish separately rather than with a fixed menu would be ideal, so that diners can pay for just what they want to eat. Finally, the refectory staff could wrap up leftover food for those who wish to take it home.

Regarding the evaluation of plate waste, participants suggested using a “waste sorting system” to send glass, plastic, etc. for recycling. Administrative personnel suggested donating leftover food to animal shelters. The participants also mentioned some challenges that could hinder the implementation of these suggestions. In particular, people are unaware about the need to reduce food waste, so new policies might not succeed no matter how many warnings are given to diners.

Some of the answers from the participants that is related how to reduce plate waste are given as examples:

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Refectory should use sorting system for bottles, plastics etc. for recycling

(Academician, 45, Woman)

It is necessary to raise awareness about reducing food waste

(Academician, 42, Man)

Leftover foods can be given to animal shelters.

(Administrative Personnel, 38, Woman)

I think food will not be left on the plate, if the quality of the food increases

(Administrative Personnel, 34, Woman)

Refectory should be open buffet system. By this way, everyone can get as much as they can eat on their plate.

(Student, 23, Woman)

Rather than fixed menu priced, pricing of each dish separately will be the best solution.

(Student, 25, Man)

3.1.2.7 Impacts of plate waste in terms of sustainability. The observation and semi-structured interview results revealed huge levels of plate waste in the university's two refectories. The main problem is the increase in plate waste and not know how to evaluate it from the sustainability perspective. Over the last few years, a wide range of organisations in developed countries have focused on the environmental, economic and social impacts of food waste (Mourad, 2016).

According to results, participants believed that plate waste caused environmental problems such as "carbon emission", economic problems such as "economic loss" and social problems such as "poverty". They drew attention to people suffering from hunger and poverty, which had many economic costs.

Some of the answers from the participants are given as examples:

Plate waste definitely causes economic loss for us

(Students, 19, Man)

Many people suffer from hunger and poverty

(Academician, 33, Woman)

Carbon emission is increasing every day

(Administrative Personnel, 40, Woman)

4. Discussion and managerial implications

According to the results of the MAXQDA analysis, there is generally no satisfaction with the meals in the university refectories. Therefore, the plate waste generated in the university refectories is high. The results of analysis for impacts of plate waste in terms of sustainability dimension support the three dimensions of sustainability, which emerged as a result of the calculation of Food Waste Calculator in our study as mentioned below.

Using the Food Waste Calculator tool (SavingFood, 2020), the total plate waste produced in one week in the university was calculated as 1,698 units for main dishes and 1,638 units for sundries like salad, bread and yoghurt. According to the university's catering firm, main dishes and sundries weighed on average 250 gr and 100 gr while the average preparation

costs were 0.7 Euro/kg and 1 Euro/kg. The university wastes 580 kg of main dishes per week at an average cost of 1,070 Euro/tonne. These figures show the environmental and economic cost of plate waste. Plate waste in the university releases 50,870.6 kg CO₂ monthly and is worth 50,634 Euros. Moreover, monthly disposal costs are 14,324 Euros.

Moreover, according to MAXQDA analysis, suggestions for plate waste such as referring to animal shelters support [Figure 4](#), which is proposed flow system for plate waste in the university as shown below.

The results clearly show that the university's plate waste is economically, environmentally and socially unsustainable. In this study, a proposed system is created to reduce plate waste in university refectory as shown in [Figure 4](#).

The results indicate that planning is needed to reduce food waste and evaluate waste in the university's refectories. First, separation bins should be prepared to categorise the disposed plate waste, such as for bread, salad, fruit and main dishes. The leftover bread can be sent to food banks and refugee camps while salads and fruits can go to pig farms. Food that cannot be used as animal feed can be delivered to recycling facilities. Given the low levels of awareness about food waste, more efforts should be made to raise awareness throughout the university through brochures, campaigns, etc.

[Figure 4](#) is proposed for making effective planning to collect food waste in university refectories. Moreover, planning within the scope of university alone will not be sufficient. This proposed flow system should be extended in the context of circular economy. It has become extremely important today to be able to evaluate food waste within the framework of the circular economy. Meat and milk wastes in particular are among the most difficult food types to be evaluated within the framework of the circular economy that we encounter in real life. Therefore, when proposing solutions for food waste, the requirements of the circular economy should also be considered. In this study, proposed flow system for plate waste in the university ([Figure 4](#)) provides a circular economy perspective, and it is taken into consideration that meat and dairy wastes from food types can also be used. For example, as [Kazançoğlu et al. \(2018\)](#) states in order to evaluate milk wastes within the framework of the circular economy, improvements should be made in the waste collection centres with the perspective of sustainability and circularity. Moreover, besides milk waste, meat waste is an essential type of food waste. [Kayikci et al. \(2019\)](#) offer a circular and central slaughterhouse proposal in their study. This proposed model aims at circularity starting from the slaughtering process of meat. However, this model can also be used for plate waste that occurs after the slaughtering process.

Furthermore, according to MAXQDA analysis, [Figure 5](#) is proposed as suitable for our results of the study. As [Figure 5](#) shows, the proposed flow system can reduce food waste in refectories and enable better capacity planning for food preparation.

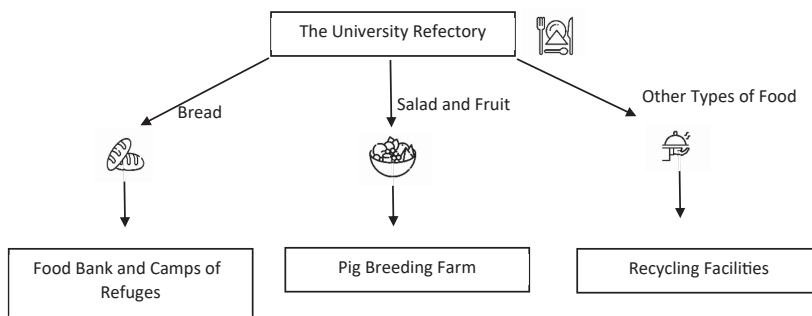


Figure 4.
Proposed flow system
for plate waste in the
university

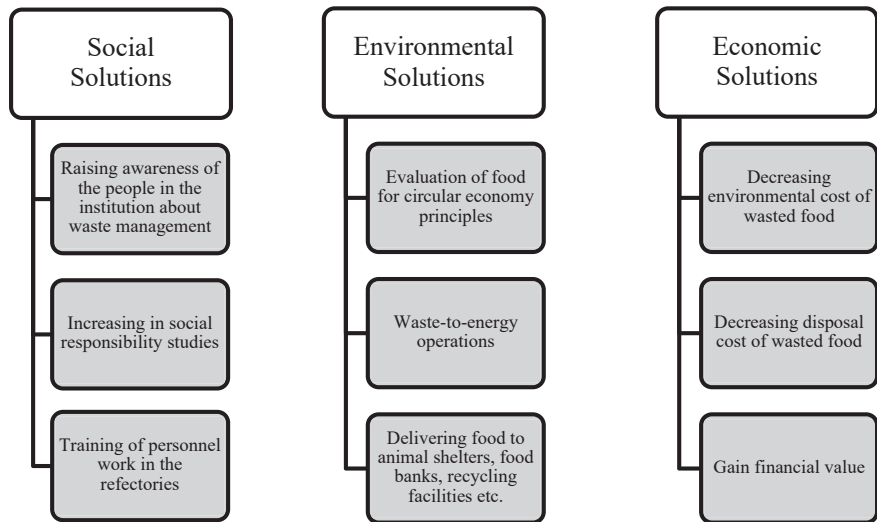


Figure 5. Social, environmental and economic benefits of proposed flow system

Socially, awareness can be increased through banners, brochures and announcements to reduce plate waste in the university. Training can be organised for refectory personnel about the separation systems to make them more knowledgeable about food waste. As already mentioned, separated wasted foods, such as bread, salads, fruit and main dishes, can be sent to food banks, animal farms, etc. This will enable the university to develop its social responsibility as an exemplary role model.

If the university's food waste is not used or recycled, it causes pollution and carbon emissions, as mentioned earlier. In contrast, the proposed flow system for the refectories can create a circular economy by separating and reusing plate waste or using it for energy production.

Finally, as calculated above, leftover food has an economic cost itself and for its disposal. In contrast, the proposed flow system reduces costs by managing food waste effectively.

5. Conclusions

Recently, food surpluses have caused increasing food waste, such as in universities, hospitals and hotels. The present study showed that this wastage is mostly caused by diners' plate waste. Given its crucial role in food waste, researchers have focused on plate waste. However, it is also important to find sustainable circular solutions as well as measuring the levels of food waste in mass consumption places and identifying the causes. Various studies have investigated plate waste in educational institutions (Hartmann *et al.*, 2021; Qian *et al.*, 2021). Furthermore, Boschini *et al.* (2020), Garcia-Herrero *et al.* (2021) and Conrad and Blackstone (2021) have studied plate waste and solutions in terms of sustainability. However, they did not focus on all three sustainability dimensions. In contrast, the present study used observations and semi-structured interviews to identify solutions for all three dimensions. Moreover, by using MAXQDA and coding, it is also aimed to put forward the reasons of dimensions numerically. Therefore, the main contribution of this study was to show the current status of plate waste in the university's refectories and suggest sustainable and circular solutions.

After the literature review on plate waste was completed, observations were made in two university refectories to determine the current status of plate waste. The university's

refectories serve an average of 20,000 diners per month. The observations revealed that there is a food waste problem. Face-to-face interviews were then conducted with 150 diners, equally sampled from students, administrative personnel and academicians.

Based on the observations, the approximate environmental and waste disposal costs were calculated. The environmental cost was 50,870.6 kg CO₂ monthly, which represents a financial cost of 50,634 Euros per month, while the monthly waste disposal cost was 14,324 Euro. Thus, food waste clearly affects the university refectory economically, environmentally and socially. To minimise food waste, a flow system to reduce food waste in the refectories and capacity planning for food preparation was proposed. This flow system would have social, environmental and economic benefits.

The results showed high levels of food waste but low awareness of food waste. Thus, an awareness-raising program about food waste in the university was proposed along with sustainable solutions within the framework of circular economy.

One limitation was that it is difficult to generalise the results since the analysis covers single university. Another limitation is that the proposed solution still requires economic incentives within the institution, even if they are acceptable. Future research should examine the kitchen side to develop better both capacity planning throughout and demand planning during food preparation.

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